

ORIGINAL ARTICLES

The Effect of Surface Sealant on Micro-Leakage and Solubility of Nano-Glassionomer Restoration,

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ABSTRACT

The aim of this study is to compare the marginal leakage of light curing nano-glassionomer cement restoration with and without unfilled surface resin sealant coating when used for cervical cavities. Also, to evaluate the solubility of nano-glassionomer cement restoration when used with and without unfilled surface resin sealant coating. Materials and methods: for microleakage testing, standardised class V cavities were prepared on the buccal surfaces of 20 sound human upper premolars. Half of the cavities (n=10) were only restored with nano-glassionomer restoration, while the other half (n=10) were restored with nano-glassionomer restoration coated with one thin coat of unfilled surface resin sealant. The restored teeth were placed in methylene blue solution for 24 hours. Then the teeth were sectioned longitudinally and analysed for dye penetration length using Image J software. For solubility testing, a total of 20 nano-glassionomer discs were prepared. The discs were classified into two groups; 10 discs were coated with two layer of the unfilled surface resin sealant while the other 10 discs were not coated. Solubility assessment was based upon modification of the ISO 4049; 2000 specification. The results showed that nano-glassionomer coated with unfilled surface resin sealant group recorded non statistically significant lower dye penetration mean value (2.943 ± 0.09659 mm) than the uncoated group (3.251 ± 0.1241 mm). For solubility, nano-glassionomer coated with unfilled surface resin sealant group recorded non statistically significant lower solubility mean value (2.054 ± 0.4987 %) than nano-glassionomer uncoated group (2.374 ± 0.06505 %). Conclusion: coating the nano- glassionomer restoration with unfilled surface resin sealant slightly improves but did not completely eliminate microleakage, nor prevent solubility of the nano-glassionomer restoration.

Key words: Nano-Glassionomer, unfilled surface resin sealant, micro-leakage, solubility.

Introduction

Non-caries cervical lesions, e.g: (abrasion, erosion and abfraction) are a challenging dental problem that requires professional attention. Their prevalence has increased due to the implementation of preventive dentistry and caries control (Li *et al.*, 2006; Owens and Johnson, 2006). Glassionomer cements (GICs) have been indicated as the restorative materials of choice for these cases. As they are capable to form satisfactory bonds with enamel and dentin, release fluoride over a prolonged period, promote good biological response and have a coefficient of thermal expansion close to that of tooth structures (Mazzaoui *et al.*, 2000; Yip *et al.*, 2001, Van Dijken and Pallesen, 2008; Francisconi *et al.*, 2009). But unfortunately degradation of GI restorations occurs. The solubility influences both the rate of degradation and their biological compatibility (Tuna and Keyf., 2006). Also solubility of GI leads to dimensional changes, loss of retention, staining and breaking in margin contours and may affect the mechanical behavior, and stability (Musanje *et al.*, 2001; Keyf *et al.*, 2006 and Malacrane *et al.*, 2006).

Recently nanotechnology which is known as the production and manipulation of materials and structures in the range of about 0.1–100 nanometers by various physical or chemical methods was applied to GICs. Reducing the dimension of the particles into nano-scale lead to a wide range of distribution, and an increasing filler load. So increasing the mechanical properties such as tensile strength, compressive strength and resistance to fracture (Chandra *et al.*, 2011).

Generally the major problem with the cervical lesions is leakage at the restoration tooth interface, particularly at the gingival margin located in dentin and cementum. This loss of marginal integrity might be occurred due to; material characteristics, polymerization shrinkage, cavity margin location, morphological and histological constituents of enamel and dentin, patient's occlusion components, insertion technique and operator

compliance with manufacturer's instructions (Owens and Johnson, 2006). Because of this, the microleakage and solubility of dental restorations are of considerable clinical importance and cannot be overlooked.

In an attempt to minimize solubility, and the undesirable marginal gap formation with cervical lesions, many improvements in the materials and placement techniques have been introduced. which included sealing the tooth/resin restoration interface with adhesive resins, lightly filled sealing resins, low viscosity surface penetrating sealants, or products specifically developed for this purpose (Araujo *et al.*, 2006; Owens and Johnson, 2006; Asaka *et al.*, 2007; Hevinga *et al.*, 2007; Magni *et al.*, 2008; Ahmed *et al.*, 2009).

Thus this study aimed to compare the marginal leakage of light curing nano-glassionomer cement restoration with and without unfilled surface resin sealant coating when used for cervical cavities. Also, to evaluate the solubility of nano-glass ionomer cement restoration when used with and without unfilled surface resin sealant coating.

Materials And Method

One Nano-glassionomer and low viscosity unfilled surface resin sealant were used in this study. Table1. Showed the materials name, composition, and manufactures.

Table 1:

Materials name	Composition	Manufacture
Ketac N 100 (Light-curing Nano-ionomer restoration)	-Aqueous paste: acidicpolyalkenoic acid, reactive resins, and nanofillers -Non-aqueous paste: FAS glass, reactive resins, and nanofillers Ketac N100 primer: (Light-cured) Vitrebond copolymer, HEMA, water, and photoinitiators.	3M ESPE, USA
OptiGuard Surface Sealant	Uncured methacrylate, ester monomers and photoinitiators	kerr MFG, Orange, CA, USA

Micro-leakage testing:

a- Selection of teeth

A total of 20 sound human upper premolars of nearly even mesio-distal dimensions were used. A digital caliber was used to measure teeth dimensions. Teeth were then, visually examined using a magnifying lens 4X and by transillumination to ensure that they were free of cracks or defects. Calculus and/or soft tissue deposits were removed from the selected teeth using a hand scaler (Ash instruments, Dentsply, UK).

b- Preparation of class V cavities:

Standardized class V cavities (2x3x1.5mm) in occlusogingival, mesiodistal and depth respectively were prepared in the gingival one third of the buccal surfaces of the selected premolars.

c- Restoration of the prepared cavities:

The cavities were restored with light-curing nano-glassionomer, following manufacturer's instructions. Half of the cavities served as group A (n=10); where cavities were only restored with nano-glassionomer restoration, while the other half served as group B (n=10); where cavities were restored with nano-glassionomer restoration, then one thin coat of unfilled surface resin sealant was applied to restoration/tooth surfaces. Then light polymerized for 15 seconds following manufacturer's instructions. Teeth were then stored in normal saline.

d- Micro-leakage assessment:

The root apices of specimens were sealed with utility wax and two coats of nail varnish (Maybelline LLC, Dist., New York, NY, USA) applied to entire tooth surface, leaving 2 mm window around the restoration margin. The specimens were then placed in 1% methylene blue solution for 24 hours at room temperature. After removal from dye solution, the teeth were washed under running tap water. The teeth were sectioned longitudinally through the restorations in a bucco-palatal plane with a low speed diamond coated disc under a water coolant. The sections were kept ready for evaluation (Owens & Johnson., 2006).

Each half of the tooth was photographed using digital camera fitted on the microscope (Scope Capture Digital Microscope, Guangdong, China) and connected with an IBM compatible personal computer using a

fixed magnification of 25X and evaluated using Image J software (Image J 1.43U, National Institute of Health, USA). Within the Image J software, all limits, sizes, frames and measured parameters were expressed in pixels. Therefore, system calibration was done to convert the pixels into absolute real world units. Calibration was made by comparing an object of known size (a ruler in this study) with a scale generated by the Image J software. The leakage path (extent of dye penetration) was traced to calculate the length of the leakage path (in mm²).

Solubility testing:

The methodology used in this study was based upon modification of the ISO 4049; 2000 specification.

a- Nano-glassionomer specimens preparation

A circular brass mold was used to create nano-glassionomer disc specimen, 10 ± 0.1 mm in diameter and 1 ± 0.1 -mm thick. The mold was supported by a glass plate of larger dimensions than the mold and covered with a mylar sheet. The mold was filled to slight excess with the nano-glassionomer. Then another glass plate, also covered with mylar sheet, was positioned on the mold and pressed manually in such a way that the plates touched the entire mold in a uniform manner. Hand pressure was applied for 20 seconds. Light-curing was through the glass slab for 20 seconds using a light-curing unit (BlueDent; BG Light LTD, Plov, Bulgaria) at 600 mW/cm². The nano-glassionomer specimens were then removed from the molds. A total of 20 specimens were prepared. The specimens were classified into two groups (n=10). Group 1; specimens were coated with two layer of the unfilled surface resin sealant. While group 2; specimens were prepared without coating with the unfilled resin surface sealant.

b- Solubility assessment:

The specimens were placed into pre-numbered glass tubes, and were then transferred to a desiccator containing silica gel to eliminate moisture at 37°C for 24 hours to allow the materials to set completely. The specimens were weighed to a precision of 0.01 gram using an analytical balance (Pocket Scale, Electronic Digital Instruments, China). This cycle process was repeated until a constant mass was achieved (M1) within the first 24 hours. 50 ml of de-ionized water were added to the specimens into the pre-numbered glass tubes and stored at 37°C in an incubator (PS.3A, Advanced Technology, Egypt) for 7 days. Then the specimens were removed from the de-ionized water, blotted dry with absorbent paper, waved in the air for 15 seconds and weighed to obtain the maximum wet mass (M2). The M2 value will not be used to determine the solubility value of the materials but it is needed to be known as it is a transition value between M1 and M3 values. Then the specimens were placed in a silica particles-containing desiccator at 23+1°C and weighed daily within 7 days to a constant dry mass (M3) to allow determination of the mass loss.

The maximum mass loss (solubility) at equilibrium was calculated for each disk using the following equations (Kefy *et al.*, 2006; Gerdolle *et al.*, 2008):

$$\text{Solubility} = (M1 - M3) / V.$$

Where; M1 is the mass of the specimen, in gram, before immersion in water;

M3 is the mass of specimen, after immersion and desiccation,

V is the volume of the specimen in mm³; $V = [(\pi * D^2) / 4] * L$ where V; volume, π ; 3.1416, D; diameter of specimen in mm, and L; thickness of specimen in mm.

Statistical analysis:

Data analysis was performed with student t-test to detect significance between groups. Statistical analysis was performed using Graphpad Prism-4 statistics software for Windows. P values ≤ 0.05 are considered to be statistically significant in all tests.

Results:

Micro-leakage (dye penetration):

It was found that nano-glassionomer coated with unfilled surface resin sealant group recorded non statistically significant lower dye penetration mean value (2.943 ± 0.09659 mm) than nano-glassionomer uncoated group (3.251 ± 0.1241 mm) as revealed by paired t-test ($t=2.26$; $p>0.05$).

Table 2: Dye penetration results (Mean values± SDs) recorded in millimetre for nano-glassionomer with and without unfilled surface resin sealant coat groups.

	Mean ± SDs	Difference	Paired t-test	
Uncoated nano-glassionomer	3.251 ± 0.1241	0.3088	t-value	P value
Coat nano-glass ionomer	2.943 ± 0.09659		2.26	0.0864 ns

ns; non-significant ($p>0.05$)**Solubility results:**

It was found that nano-glassionomer coated with unfilled surface resin sealant group recorded non statistically significant lower solubility mean value (2.054 ± 0.4987 %) than nano-glassionomer uncoated group (2.374 ± 0.06505 %) as revealed by paired t-test ($t=0.7378$; $p>0.05$).

Table 3: Solubility test results for nano-glassionomer with and without unfilled surface resin sealant coated groups.

Solubility (g)		
Initial weight (Mean±SD)		
	No coat	Coat
	0.35503±0.0179	0.42833±0.0387
Final weight (Mean±SD)		
	No coat	Coat
	0.3466±0.01054	0.4195323±0.015
Difference (Mean±SD)		
	No coat	Coat
	0.00843±0.0004	0.0088±0.0037
Paired t-test	t-value	0.7378
	P-value	0.5375 ns

ns; non-significant ($p>0.05$)**Discussion:**

Newly introduced light cured nano-glassionomer cement was tested in this study. It combined the benefits of resin modified light curing glassionomer, and the bonded nanofiller technology. They supposed to have excellent aesthetics, superb polish, high wear resistance, and advantage of fluoride release. Active researches were being conducted on the new light curing glassionomer cements because of their unknown properties and handling protocols.

Resin restoration materials rely on adhesive bonding to produce a seal between the restoration and tooth structure. Attempt to seal the marginal gap between tooth restoration interface by coating the polymerized resin restorative materials with bonding agent or resin sealants had been reported. It was thought that unfilled surface resin sealant would fill the structural microdefects and microfissures that are formed on the composite and resin modified glassionomer cement by the capillary action, and penetrates deeply in to the interfacial microgaps, to provide marginal sealing. In addition unfilled resin sealant coating protects the restorations from water contamination and desiccation in the initial setting stages (Ramos *et al.*, 2000; Erhardt *et al.*, 2002; Owen and Johnson., 2006).

In the present study class V cavities restored with nano-glassionomer coated with unfilled surface resin sealant showed insignificant lower micro-leakage values than class V cavities restored with nano-glassionomer restoration uncoated with unfilled surface resin sealant. This might be due to dehydration of the restorations during specimens' preparation, especially during application and drying of the nail varnish. Several studies showed that accidentally drying out a restoration prior to dye immersion increased microleakage for resin-modified glassionomer. As contraction under desiccating conditions might disrupts the bond at tooth restoration margins. Moreover if contraction was far greater than the expansion by water absorption, there could be a resulting increase in micro-leakage (Bouschlicher *et al.*, 1996; Hattab *et al.*, 2001; Haznedaroglu *et al.*, 2012).

Moreover regarding solubility of nano-glassionomer coated with unfilled surface resin sealant showed insignificant lower solubility values than the uncoated specimens. This might be due to that nano-glassionomer, contained a resin HEMA (hydroxy ethylmethacrylate) which is hydrophilic in nature. Which lead to an increased water sorption and subsequent plasticity and hygroscopic expansion of the restoration. This was beside the dissolution mechanism of conventional glass ionomer cement in water, which was attributed to two factors: firstly, they contain sodium that forms water soluble salts with the matrix forming anions. Secondly, free calcium and aluminum ions that are present in the fresh cement can be removed by chemical reactions. In addition, aluminum ions react rather slowly with the matrix forming anions and before they are bound, is vulnerable to early water leaching (Deniz *et al.*, 1998; Carvalho *et al.*, 2003; Ymazaki *et al.*, 2007; and Geetha *et al.*, 2011).

Data of the present study supported the findings of D'Alpino *et al.*, 2006 and Ahmed *et al.*, 2009, that there was absence of compatibility between the types of resins forming the surface penetrating resin sealant and that

was present in the nano-glassionomer restorations. Which might be the reason of minor improvement of the solubility and the micro-leakage of nano-glassionomer restorations when coated with unfilled surface resin sealant.

Conclusion:

Within the limitations of this study, it can be concluded that, coating the nano-glassionomer restoration with unfilled surface resin sealant slightly improves but did not completely eliminate micro-leakage, nor prevent solubility of the nano-glassionomers.

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